Distribution System of the Future

OAK RIDGE NATIONAL LABORATORY
U. S. DEPARTMENT OF ENERGY

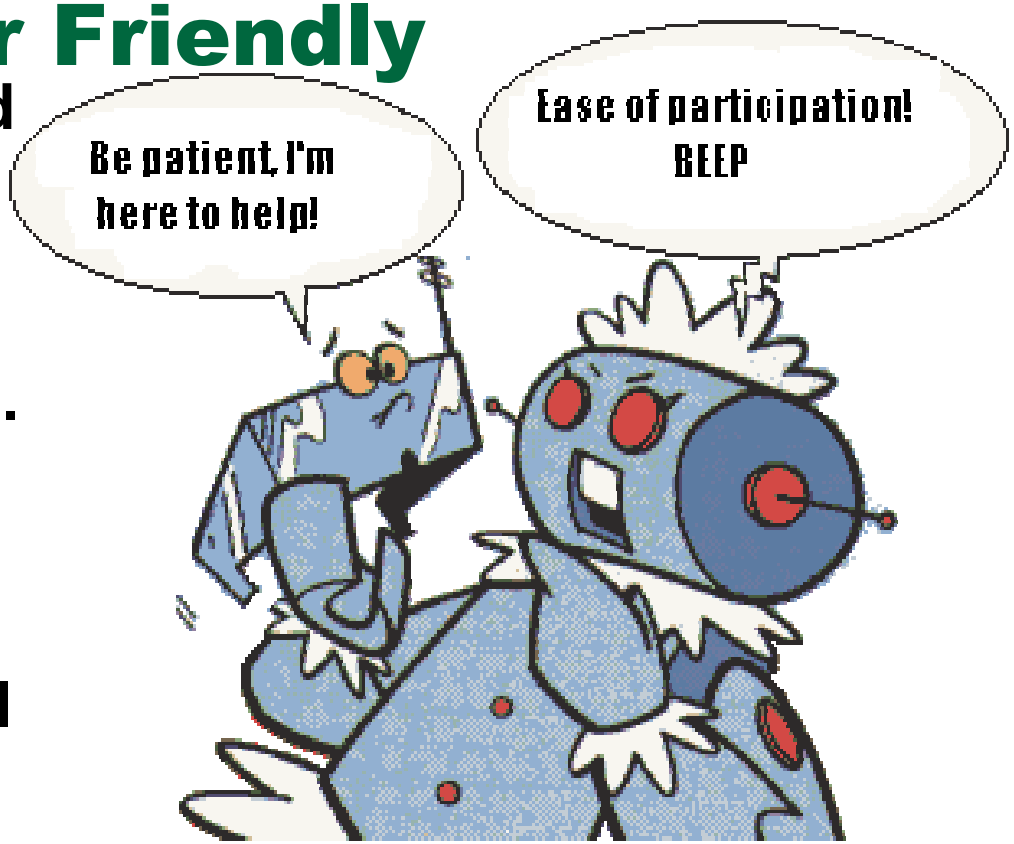
UT-BATTELLE

Distribution System of the Future
- Questions -

- What will it look like?
- Capabilities and functions?
- Key time frames for transition to the future?
- Specific objectives and topics for study?
- Near term opportunities?
- Availability of supporting technologies?
- Key technology needs?
- Paths for question exploration and resolution.

Increased Complexity & Diversity But More "Engineered", Flexible and User Friendly

- Versatile and sophisticated safety features.
- New users will find it simple to participate in the market to meet their needs.
- Reliability and power quality at whatever level each user requires.
- The level of complexity will be transparent to the user.



Desirable Future Capabilities

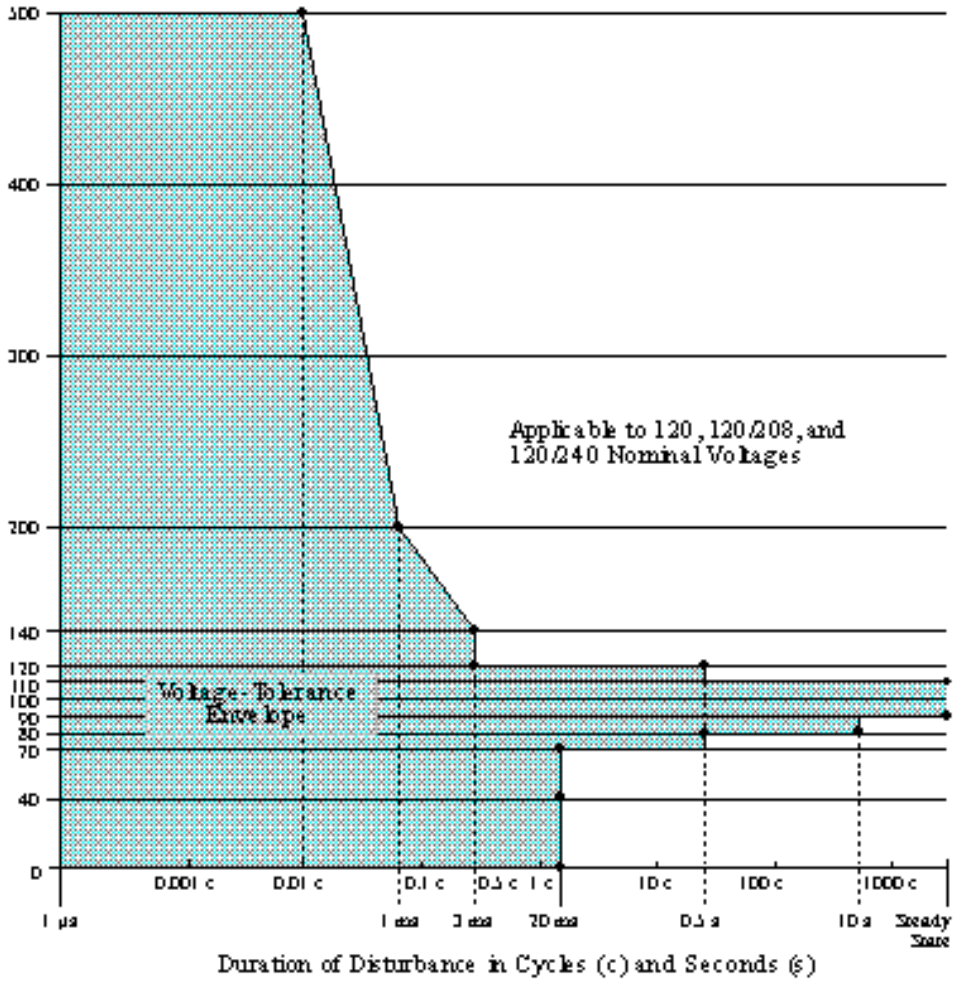
- Versatile, sophisticated protection that will allow many configuration changes (generation and distribution) and variations in fault current.
- Enabling local dispatch of voltage regulation, power quality and reliability levels.
- Flexible: accommodates growth *and* change.
- Accommodate power from an array of technologically different sources of central and distributed energy and storage.
- Enabling central generator and responsive load dispatch commands; for markets and for reliability.

Basic Functions Provided by the Future System

- ***Safety:*** **Protect the public, utility personnel, facilities and equipment.**
- ***Reliability and Power Quality:*** **Accommodate the different customer needs.**
- ***Market Choice:*** **Accommodate multiple suppliers & customers in a fluid market.**
- ***Economy and Efficiency:*** **Do all of this as economically and efficiently as possible.**

Time Frames for a Changing System

- ***Near Term:*** **Expand the capabilities of existing facilities through retrofits and operational changes**
- ***Mid Term:*** **The system is constantly expanding, modify designs of new facilities to provide added capability, and dovetail with future systems**
- ***Future:*** **Clean slate – see what technology can provide to provide the desired functionality**



Specific Objectives and Topics

- To what extent will the distribution system enable provision of local levels of power quality and reliability?
- How should contingencies be detected and responded to? What are the safety, reliability, power quality, and economic concerns?
- How should rate structures and tariff issues be addressed (especially to motivate desired behaviors – from the distribution company & from loads and generators)?
- Should performance incentives be offered to distribution companies?
- How will the distribution system interact with energy supply (local and remote), storage and demand?
- To what extent *must* the distribution company be involved when distributed generation and responsive load interact with the bulk power system for energy sales and/or providing reliability services? To what extent *should* the distribution company to be involved? (What is minimally required vs what is most useful.)

Near Term Advances

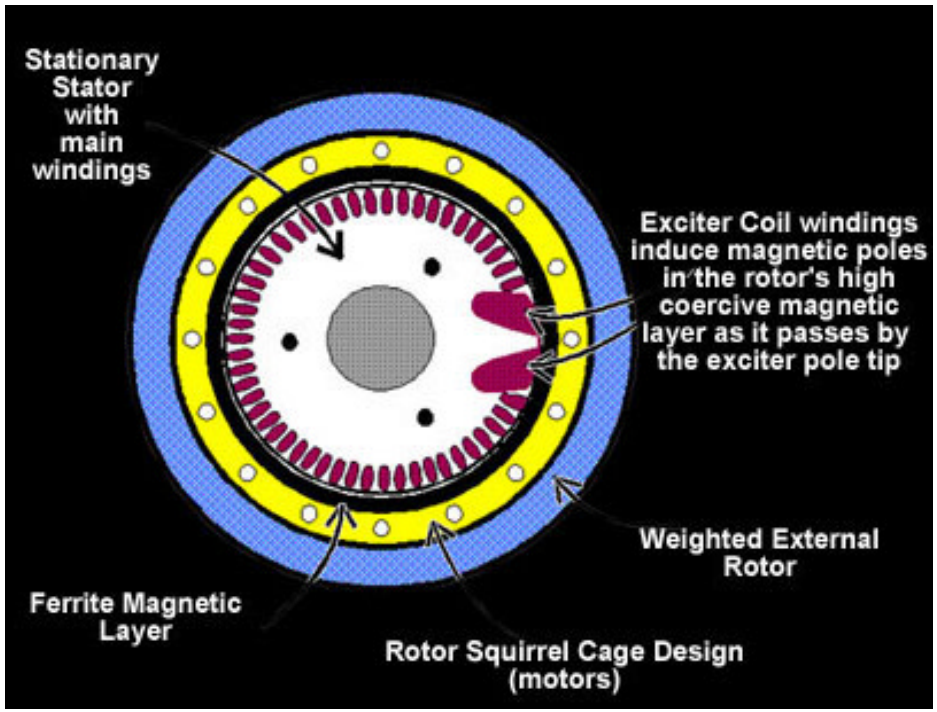
- Responsive load that reacts to market conditions.
- Large bandwidth communication link, advanced low cost meters and gateways to interface with responsive loads, distributed generation, storage, and the customer interface.
- Low cost DC power distribution providing a link for DER and energy storage.
- Low cost synchronization and rapid transfer between stand alone and connected modes of operation.
- Relaying that operates with varying levels of available fault current.

Technology Baselining

- Research and baseline applicable existing technologies.
- Establish factors such as performance, cost, reliability.
- Consider all the needs from the load, local generator or storage device, up to and including the substation.

Evaluation of Supporting Technologies

- What must be developed near and long term?
- What design concepts and engineering methods must be established and proven?
- Demonstrations of economic incentives for power quality.
- Education, workshops, websites, etc. on existing technologies.



Key Technology Needs

- Modeling and planning tools (robust, versatile, and possibly permits reliance on rules of thumb.)
  - Dynamic network models
  - System response models
  - Aggregation of load and generation
  - Stability/voltage collapse
  - Modeling for protection of personnel and equipment
- Power electronic interface with low cost, adaptable, reliable, high power components - low cost silicon carbide switches.
- Low cost communication, gateways, control architecture.
- Energy storage.

The Path Forward

- Baseline technologies, identify issues, draft a program vision and roadmap, propose industry participants.
- Prepare discussion papers on each issue.
- Host a series of meetings with industry experts to discuss issues.
- Initiate and manage an e-mail dialog.
- Arrive at a fully developed, detailed, consensus-based program outline with broad industry support.